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Convergence of violent crime in the United States: Time series test of nonlinear

by

A.H. Baharom[1] *, Muzafar Shah Habibullah and R.C. Royfaizal*

ABSTRACT

This study examines the violent crime convergence among the fifty one states in the United States. The chosen method for this analysis is nonlinear unit root test due to Kapetanios et al. (KSS, 2003), which was later extended by Chong et al. (CHLL, 2008). KSS-CHLL nonlinear unit root was applied for the test of nonlinear convergence among the fifty one states with respect to the national average for the period 1960 to 2007. Result of the study indicates that eight cases of long run converging, two cases of catching up, while the remainder forty one are diverging from the national average.

I. INTRODUCTION

The increase in the public's concern about crime in the United States is generally parallel with the amount of intense media focus on the issue of the abnormally horrendous crimes and on the types of individuals who commit them. Arin (2008) mentioned that Americans have always had a peculiar relationship with crime and criminals. Each generation seems to fret about unprecedented lawlessness, while bestowing on its most outrageous criminals the kind of celebrity reserved for folk heroes and movie stars crime rates vary greatly across the states. Generally looking at the statistics over the period 1960-2007, North Dakota had by far the lowest average crime rates, for violent crime and the most notorious state is Washington D.C. The average crime rates per 100,000 for these states are 64.91 and 1826.87 respectively. Densely populated states such as New York and New Jersey also had crime rates well below the national average. Southern states had the highest overall crime rates.

United States overall crime rate is displayed in two indices. The violent crime index (which is the subject of study) comprises homicide, forcible rape, robbery and assault. Thus the issue of gun control is paramount in today's society if we are to reduce the rising numbers of violent crimes. In a society where individualism, independence and equality are all seen as highly desirable values, public's growing affinity for firearms, a tool that enables its owners to effectuate those values, would become a widespread phenomenon. It is unfortunate, however, that guns have come to act as symbols of these values for many Americans, when in truth, all they do is perpetuate criminal activity.

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Brown (2007) mentioned that one of the great and intractable weaknesses of American democracy is its inability to create and maintain rational criminal law policy. The politics of crime are perennially perverse: the electorate demands that legislatures enact more crimes and tougher sentences, and no interest groups or countervailing political forces lobby against those preferences. Crime in United States could be seen as being on the rise from either a sociological perspective such as an increase in underlying problems in the lives of individuals and in the community or typically economic, social, and/or psychological in nature. While it cannot be denied that genetic and biological factors involved in the development of an individual's propensity towards committing crimes, environment also plays a key role in this arena. Different punishment in different states also contributes to enormously varying crime among the states. People from problematic backgrounds or especially difficult circumstances are not only more likely to participate in criminal activities, but are also more likely to continue their destructive activities to the point at which serious run-ins with the law develop. Unfortunately, there is no reliable data on changes in the economic background of violent criminals. It could be assumed that the numbers had risen faster in poor societies because of the violence that explodes everyday, whether it includes gangs or other individual infractions.

This paper is organized as follows. In the following section some related literatures are reviewed. In section 3, we discuss about the crime incidence throughout the period of study for the fifty one states in the United States while in section 4, we discuss the nonlinear unit root procedure employed in the study. In section 5, empirical results are discussed followed by the last section that contains our conclusion.

II. A REVIEW OF RELATED LITERATURE

As far as the author's knowledge and information concerned, there are no researches done on the subject of crime convergence among states/regions. Most of researches on crime originate from the seminal paper by Becker (1968) and Ehrlich (1973).Becker (1968) emphasizes on the fundamental of supply and demand of crime, more specifically, the cost and benefit of crime. Becker's work was later extended by Ehrlich (1973), who initiated a crime model by including the role of opportunity cost between illegal and legal work.

One of the researches on crime in the United States was done by Brush (2007), who conducted and compared cross-sectional and time series analyses of United States counties, interestingly, the results are in contradiction, income inequality is positively associated with crime rates in the cross section analysis, but it is negatively associated with crime rates in the time-series analysis. In another research on the United States, Rafael and Juan (2008) explained that some workers become criminals, depending on their luck in the labour market, the expected punishment, and individual shock that they call 'meanness'. It is this meanness level that a penal system based on 'retribution' tries to detect when deciding the severity of the punishment.

Magnus and Matz (2008) also in their study in the United States, went a step further diverting from the traditional aggregated measures, whereby they separated the effects of permanent and transitory income. They reported that while an increase in inequality in permanent income yields a positive and significant effect on total crimes and property crimes, an increase in inequality in the transitory income and traditional aggregated measures yields insignificant effect. If this holds, it will be interesting to see different states in the United States, performing in our study.

III. SOME STYLISED FACTS ON CRIME IN THE UNITED STATES

Figure 1 reports the situation of violent crime in the United States for 1960-2007, it can be observed that, crime in the United States has fluctuated considerably over the course of the last half-century, rising significantly in the late 1960s and 1970s, peaking in the 1980s and then decreasing considerably in the growth. Murder is the largest contributor to the violent crime, while assault is the smallest. Table 1 displays the descriptive statistics for all the fifty one states in the United States. Generally looking at the statistics over the period 1960-2007, North Dakota had by far the lowest average crime rates, for violent crime and the most notorious state is Washington D.C. The average crime rates per 100,000 for these states are 64.91 and 1826.87 respectively.

IV. NONLINEAR TEST OF VIOLENT CRIME CONVERGENCE

Oxley and Greaskey (1995) argue that the rejection of convergence by the time series test should not be necessarily taken as an evidence of divergence, because some countries may still be in the transitional process of convergence. Datta (2003) argues that disparities among countries are most likely attributable to catching up rather than divergence and he pointed out that nonlinearity may affect the power of the time series based test, which is under the linear and time-invariant assumptions. Let $CRIME_{STATE,}$ and $CRIME_{AVERAGE,}$ be the violent crime of the each state in United States and the average of violent crime in United States respectively. Consider the model:

$$\Delta z_t = \lambda + \phi z_{t-1} + \alpha t + \sum_{k=1}^{n} \delta_k \Delta z_{t-k} + \varepsilon_t \qquad (1)$$

where z_t = log $CRIME_{STATE,}$ - log $CRIME_{AVERAGE,}$ λ is the mean of z_t and ε_t refers to the error term. The test of catching up and long-run converging needs the violent crimes differential to be stationary. Empirically, the absence of unit root ($\phi < 0$), means either catching up in the presence of deterministic trend ($\alpha \neq 0$), or long-run converging if the deterministic trend is absent ($\alpha = 0$). If the violent crimes differential contains a unit root ($\phi = 0$), then the violent crimes of the state and average crime are said to diverge over time. But, equation (1) may not be able to detect convergence if z_t is nonlinear.

Kapetanios *et al.* (2003) extend the augmented Dickey-Fuller (ADF) unit root test to overcome the nonlinearity issues by incorporating nonlinearity as characterized by the Smooth Transition Autoregressive (STAR) process:

$$\Delta y_t = \sum_{j=1}^{\rho} \rho_j \Delta y_{t-1} + \eta y_{t-1}^3 + \varepsilon_t \qquad (2)$$

whereby

$$y_t = z_t - \hat{\alpha} - \hat{\beta} t$$

is the de-meaned and de-trended series with $\hat{\alpha}$ and $\hat{\beta}$ being the least squares estimators obtained from regressing z_t on a constant and a trend terms. Even though this test is useful in the study of nonlinear convergence, it failed to tell the significance of the deterministic trend, therefore it is not directly applicable here. There is a way to distinguish between long-run converging and catching up in nonlinear by using modified time series test of convergence proposed by Chong *et al.* (2008). They incorporate an additive intercept (β) and trend component [*G* (trend)] into equation 2 to yield:

$$\Delta x_t = \beta + \sum_{j=1}^{\rho} \rho_j \Delta x_{t-j} + \eta x_{t-1}^3 + \theta G(trend) + \xi_t \qquad (3)$$

whereby x_t is the original series under this study, which is different from the de-meaned and de-trended series y_t . *G* (trend) is the trend component of specific functional form. Two commonly used trend variables are the linear trend and square of the trend. ξ_t is the error term. The absence of nonlinear unit root (η < 0) implies either nonlinear catching up, given the presence of deterministic trend ($\theta \neq 0$), or nonlinear long-run converging if deterministic trend is absent (θ = 0). However, if the interest rates differential contains a nonlinear unit root (η = 0), the interest rates of the two contrasting are said to diverge over time.

The data set of this study consists of annual number of violent crime per 100 000 of each state in United States and the average violent crime per 100 000 of United States as the main reference. The data originates from the Federal Bureau of Investigation (FBI), and subsequently made available on the internet by United States Disaster Center The total sample is spanning from 1960 to 2006. All variables were expressed in natural logs.

IV. RESULTS AND CONCLUSION

If the state violent crime converges to the average violent crime, then it is natural to say that the average violent crime has influence on the state violent crime in other words, differing punishment among the states, and differing attributes is not significant The modified KSS-CHLL nonlinear unit root test is applied to the crimes gaps (with respect to the average crime) of these 51 states.

Table 2 shows the results of KSS-CHLL test with constant and linear trend. The estimators of the parameters of interest in equation (3), η and θ, together with the corresponding *t*-statistics are reported. Note that the 10%, 5% and 1% simulated critical *t* values for 50 observations are -3.06, -3.38 and -4.05[2] respectively. Unit root is found in 39 states crime gaps, which provides evidence against average violent crime convergence between these sates with respect to the average violent crime in the United States. On the other hand, no unit root is found in the violent crime gaps of Arizona, Colorado, Hawaii, Idaho, Kansas, Louisiana, Minnesota, New Hampshire, Oklahoma, South Dakota, Washington DC, Wisconsin and Wyoming, meaning the rejection of violent crimes divergence. Therefore, we can further investigate whether these thirteen states are in the process of catching up or have attained long-run converging with respect to the average crime in the United States. The 10%, 5% and 1% simulated *t*-critical values of the left (right) tail are -2.63 (2.63), -3.07 (3.02) and -3.78 (3.76) respectively. It is observed that the trend term is significant in the case of Kansas, Oklahoma and Wisconsin, which provide evidence supporting catching up. The remainder ten states are said to have attained long-run converging with the average violent crime in the United States.

For comparison, we also perform the KSS-CHLL test with a constant and a nonlinear trend and the results are reported in Table 3. Note that the 10%, 5% and 1% simulated critical *t* values for 50 observations are -3.10, -3.44 and -4.07 respectively. As for θ, the corresponding critical values for the left (right) tail are -2.66 (2.65), -3.02 (2.99) and -3.86 (3.81) respectively. It can be observed from the *t*-statistics of the estimated η, Arizona, Colorado, Hawaii, Idaho, Louisiana, New Hampshire, South Dakota and Wyoming have attained long-run converging with respect to the average violent crime in the United States. Meanwhile, Kansas and Minnesota are in the process of catching up. The remainder violent crimes in the forty-one states are diverging from the average violent crime in the United States.

[2] See Chong T.T.-L. *et al.* (2008).

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Figure 1 Violent Crime in the United States

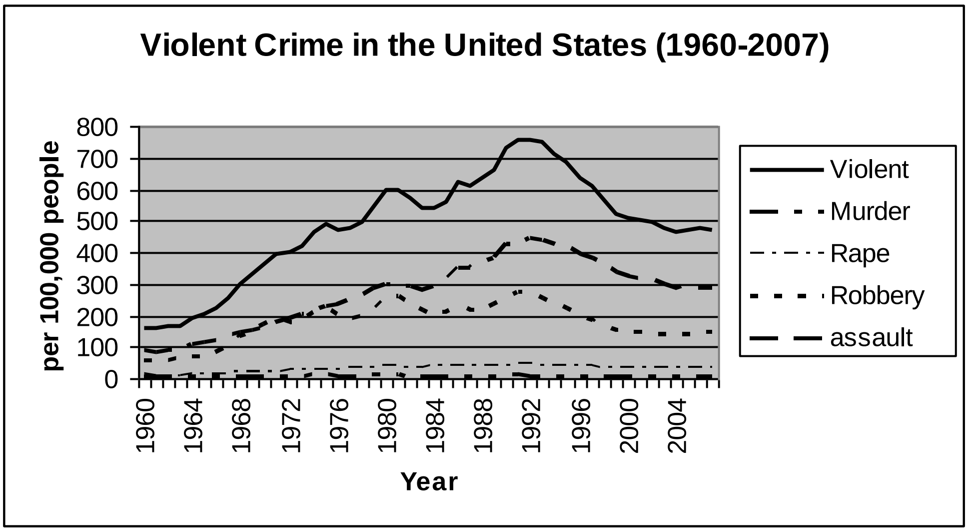

Table 1: Descriptive Statistics (number of violent crime per 100 000)

	Mean	Maximum	Minimum	Std. Dev.
ALABAMA	464.219	872	200	157.1525
ALASKA	515.9262	766	149	167.7939
ARIZONA	527.381	715	192	131.9858
ARKANSAS	389.6667	595	136	127.7367
CALIFORNIA	715.3095	1120	282	219.2979
COLORADO	419.4762	579	153	103.0738
CONNECTICUT	330.1905	554	70	125.5251
DELAWARE	500.6214	762.4	111.1	171.4389
FLORIDA	818.831	1244.3	299.5	251.9374
GEORGIA	495.0524	756.3	189.3	152.6593
HAWAII	226.5548	299.5	69.1	64.83486
IDAHO	222.6238	322	66.4	69.31066
ILLINOIS	695.3119	1039.2	322.7	188.2206
INDIANA	341.9929	537	137.1	104.7307
IOWA	207.1167	354.4	38.7	91.27651
KANSAS	336.4333	510.8	107.1	104.1352
KENTUCKY	284.2952	535.5	108.9	87.01267
LOUISIANA	628.6119	1061.7	66.3	232.417
MAINE	133.3071	224.7	44	44.95634
MARYLAND	754.7024	1000.1	285.1	156.8829
MASSACHUSETS	488.1595	804.9	98.5	185.59
MICHIGAN	618.7833	803.9	297.6	124.0722
MINNESOTA	242.1405	359	86.5	72.02544
MISSISSIPPI	314.3881	502.8	113.8	91.83831
MISSOURI	511.5214	763	235.4	125.7825
MONTANA	188.1429	365	72.2	72.88078
NEBRASKA	261.4262	451.4	57.7	96.81764
NEVADA	638.9262	1001.9	216.6	194.0145
NEW HAMPSHIRE	115.3143	179.8	23.3	41.40538
NEW JERSEY	450.0286	647.6	153.9	139.7823
NEW MEXICO	627.5238	961.4	198.9	207.8986
NEW YORK	778.4905	1180.9	325.4	247.677
NORTH CAROLINA	474.6524	681	259.6	104.0176
NORTH DAKOTA	64.91429	127.9	27.7	21.67608
OHIO	378.5738	561.8	124.8	100.9657
OKLAHOMA	415.2119	664.1	134.5	149.6973
OREGON	398.9167	551.1	120.6	127.8874
PENNSYLVANIA	344.781	480.3	131	91.55285
RHODE ISLAND	306.1905	462	78.5	91.60317
SOUTH CAROLINA	667.0333	1030.5	177.2	251.3506
SOUTH DAKOTA	147.7333	227.6	59	42.2566
TENNESSEE	519.7619	789.7	138.7	200.9663
TEXAS	519.3786	840.1	199.3	156.087
UTAH	240.6119	334	89.5	63.75156
VERMONT	110.3738	184.2	19.8	39.10197
VIRGINIA	309.4095	380.9	227.6	38.47368
WASHINGTON	373.581	534.5	103	107.8165
WASHINGTON DC	1826.876	2921.8	722.8	491.5986
WEST VIRGINIA	182.9286	350.7	78	63.10818
WISCONSIN	189.8167	284	46.1	72.36753
WYOMING	238.1476	430.1	75.6	81.38964

Table 2: KSS-CHLL test with constant and linear trend

Series	Lag	η		θ		AR (2)
		Estimator	*t*- statistic	Estimator	*t*- statistic	(p-value)
Alaska	0	-1.3146	-1.6433	0.00171	1.1851	0.8013
Alabama	0	-0.9476	-1.9800	0.00005	0.0539	0.2900
Arkansas	0	-0.7394	-1.3151	0.00141	1.7178	0.5936
Arizona	0	-1.2470	-4.1702***	-0.00085	-1.0793	0.4190
California	3	-0.1783	-1.7674	-0.00085	-1.5080	0.7983
Colorado	2	-3.4956	-3.1101*	-0.00130	-1.2536	0.2251
Connecticut	0	-0.0087	-0.2982	-0.00205	-2.2302	0.5032
Delaware	0	-1.1289	-1.8920	0.00262	1.4758	0.6344
Florida	0	-0.1049	-1.5201	-0.00017	-0.3242	0.8920
Georgia	1	-1.9782	-2.4014	-0.00015	-0.2164	0.4811
Hawaii	3	-0.3136	-5.0106***	0.00300	1.4353	0.6114
Iowa	3	-0.0550	-2.2330	0.00199	0.9626	0.8723
Idaho	1	-0.1749	-3.9196**	0.00250	1.7533	0.1840
Illinois	0	-0.0685	-1.7878	-0.00035	-0.3058	0.1051
Indiana	0	-0.6986	-1.7395	-0.00035	-0.5258	0.6789
Kansas	3	-1.9341	-3.7004**	0.00387	3.3678**	0.1706
Kentucky	0	-0.5759	-2.7099	-0.00059	-0.6171	0.8543
Louisiana	0	-0.3662	-6.7425***	-0.00450	-1.1579	0.8939
Massachusets	0	-0.1018	-1.2078	-0.00174	-2.2829	0.6942
Maryland	0	-0.1814	-2.8355	-0.00166	-2.1210	0.3868
Maine	3	-0.0488	-2.5086	-0.00261	-1.6856	0.1897
Michigan	0	-0.2793	-1.6142	-0.00159	-1.2182	0.2345
Minnesota	2	-0.2853	-3.5357**	0.00209	2.3172	0.5943
Missouri	2	-0.2642	-0.7630	0.00084	1.1146	0.6925
Mississippi	0	-0.9402	-2.7729	0.00068	0.4237	0.7801
Montana	0	-0.0412	-1.4809	0.00098	0.5320	0.2717
North Carolina	3	-0.1097	-0.5403	0.00115	1.3451	0.8543
North Dakota	0	-0.0211	-1.9953	0.00144	0.7389	0.7232
Nebraska	0	-0.1479	-2.1783	0.00206	1.1444	0.9074
New Hampshire	0	-0.0596	-3.7013**	0.00418	1.6818	0.6978
New Jersey	0	-1.2744	-0.7085	-0.00086	-1.3809	0.2825
New Mexico	0	-0.6004	-2.3903	0.00203	1.6679	0.6231
Nevada	1	-0.4518	-2.2752	0.00011	0.0916	0.7071
New York	0	-0.0866	-1.3389	-0.00276	-2.4640	0.7079
Ohio	0	-1.2002	-1.8706	-0.00064	-1.1347	0.5247
Oklahoma	3	-2.2725	-3.2533*	0.00216	2.8021*	0.1298
Oregon	0	-0.3988	-1.2558	-0.00170	-2.2613	0.8433
Pennsylvania	0	-1.1562	-1.9832	0.00094	1.4171	0.5618
Rhode Island	1	-0.1101	-1.8693	-0.00250	-2.7321*	0.7036
South carolina	0	-0.6825	-2.2077	0.00434	2.0559	0.5622
South Dakota	2	-0.0915	-3.3627*	-0.00005	-0.0360	0.6516
Tennessee	3	-0.2734	-1.0565	0.00166	1.5778	0.9241
Texas	0	-1.3794	-2.1089	0.00028	0.4751	0.8585
Utah	0	-0.2429	-2.6666	-0.00018	-0.2103	0.5986
Virginia	0	-0.1613	-0.8079	0.00068	0.6560	0.3431
Vermont	3	-0.0232	-1.8316	0.00163	0.7424	0.8926
Washinghton DC	1	-0.0316	-3.1320*	-0.00213	-1.7785	0.9145
Washington	0	-0.1569	-1.1540	-0.00101	-1.2876	0.4036
Wisconsin	1	-0.1400	-3.4415**	0.00705	3.3265**	0.4492
West Virginia	0	-0.0218	-0.7918	0.00188	1.6747	0.3870
Wyoming	0	-0.3356	-3.8451**	0.00363	1.9090	0.7872

Notes: Asterisks ***, ** and * denote significance at 1%, 5% and 10% respectively.

Table 3: KSS-CHLL test with constant and nonlinear trend

Series	Lag	η		θ		AR (2)
		Estimator	*t*- statistic	Estimator	*t*- statistic	(p-value)
Alaska	0	-1.4673	-1.7589	0.0000	1.3401	0.8139
Alabama	0	-0.9790	-2.1682	0.0000	-0.1361	0.2913
Arkansas	0	-0.8833	-1.5388	0.0000	1.9041	0.5671
Arizona	0	-1.1878	-4.2157***	0.0000	-0.9332	0.4135
California	3	-0.2182	-2.1518	0.0000	-2.0918	0.8382
Colorado	2	-3.5986	-3.1723*	0.0000	-1.3582	0.2419
Connecticut	0	-0.0238	-0.9404	0.0000	-2.2167	0.6035
Delaware	0	-1.1333	-1.9415	0.0001	1.5408	0.5462
Florida	0	-0.1064	-1.5627	0.0000	-0.7953	0.8993
Georgia	1	-1.9831	-2.4512	0.0000	-0.2995	0.4835
Hawaii	3	-0.3018	-5.0790***	0.0001	1.3864	0.5897
Iowa	3	-0.0434	-2.3864	0.0000	0.6656	0.8038
Idaho	1	-0.1541	-3.7813**	0.0000	1.3755	0.2020
Illinois	0	-0.0686	-1.9857	0.0000	-0.4620	0.1032
Indiana	0	-0.6858	-1.6849	0.0000	-0.4086	0.6779
Kansas	3	-1.4753	-3.1655*	0.0001	2.8272*	0.1139
Kentucky	0	-0.5709	-2.7415	0.0000	-0.6497	0.8467
Louisiana	0	-0.3724	-6.8464***	-0.0001	-1.4328	0.8132
Massachusets	0	-0.1408	-1.8684	0.0000	-2.3040	0.7443
Maryland	0	-0.1805	-2.7632	0.0000	-1.8348	0.2480
Maine	3	-0.0518	-2.4876	-0.0001	-1.6087	0.2064
Michigan	0	-0.1477	-1.0518	0.0000	-0.4726	0.3646
Minnesota	2	-0.3154	-3.9321**	0.0001	2.8406*	0.6659
Missouri	2	-0.3369	-1.1295	0.0000	1.2051	0.7249
Mississippi	0	-0.9573	-2.8029	0.0000	0.5412	0.7711
Montana	0	-0.0420	-1.5466	0.0000	0.6706	0.2987
North Carolina	3	-0.1936	-1.0868	0.0000	1.0848	0.8073
North Dakota	0	-0.0239	-2.2611	0.0001	1.4804	0.7224
Nebraska	0	-0.1221	-1.9801	0.0000	0.7646	0.9702
New Hampshire	0	-0.0536	-3.5748**	0.0001	1.3759	0.6075
New Jersey	0	-1.7668	-0.9509	0.0000	-1.5615	0.2777
New Mexico	0	-0.5579	-2.1253	0.0000	1.3368	0.6377
Nevada	1	-0.4556	-2.2524	0.0000	0.0195	0.7217
New York	0	-0.1243	-1.6302	-0.0001	-2.5294	0.5807
Ohio	0	-1.3236	-2.0396	0.0000	-1.1448	0.5991
Oklahoma	3	-2.0880	-2.8547	0.0000	2.1745	0.1659
Oregon	0	-0.5497	-1.7896	0.0000	-2.4304	0.8080
Pennsylvania	0	-1.3198	-2.2445	0.0000	1.7792	0.5129
Rhode Island	1	-0.1425	-2.5690	0.0000	-2.6729*	0.7564
South carolina	0	-0.8718	-2.1793	0.0001	2.0154	0.6522
South Dakota	2	-0.0919	-3.3897*	0.0000	0.4086	0.6493
Tennessee	3	-0.5245	-1.6232	0.0001	2.0154	0.8187
Texas	0	-1.4123	-2.1638	0.0000	0.4011	0.8707
Utah	0	-0.2431	-2.6973	0.0000	-0.2865	0.6072
Virginia	0	-0.1672	-1.0784	0.0000	0.9779	0.3467
Vermont	3	-0.0210	-1.7833	0.0000	0.6008	0.8118
Washington DC	1	-0.0295	-2.9997	0.0000	-1.5680	0.9599
Washington	0	-0.1997	-1.6183	0.0000	-1.1235	0.4056
Wisconsin	0	-0.0615	-2.1150	0.0001	2.0358	0.1286
West Virginia	0	-0.0311	-1.1334	0.0000	1.8495	0.3756
Wyoming	0	-0.3218	-3.6489**	0.0001	1.4339	0.7113

Notes: Asterisks ***, ** and * denote significance at 1%, 5% and 10% respectively.